

MAGNETIC SUSCEPTIBILITIES OF SOLUTIONS OF SODIUM  
AND POTASSIUM NITRATES

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**ABSTRACT.** Dia-magnetic susceptibilities of solutions of sodium and potassium nitrate have been determined over a wide range of concentration (1 to 20%), employing a modified form of Quinke's method with a photographic recording arrangement. The susceptibility-concentration graph is, in each case, a straight line cutting the susceptibility axis at a point corresponding to the susceptibility of pure water ( $-0.72 \times 10^{-6}$ ), the maximum departure from linearity being not more than 1%. The gram-ionic susceptibility of  $\text{NO}_3^-$  calculated from these measurements, using the theoretically calculated values for  $\text{Na}^+$  and  $\text{K}^+$ , is different in each case, being less for the potassium salt. In view of the fact that there is a lack of agreement between the values for  $\text{Na}^+$  and  $\text{K}^+$  arrived at by different workers and the theoretical values calculated by different methods, no definite conclusion can be drawn with regard to the specific influence of the positive ion. It is, however, clear that the experimental values are, on the whole, much less than the theoretical value for  $\text{NO}_3^-$ , which is an indication of ionic deformation.

## I N T R O D U C T I O N

In a previous paper,<sup>1</sup> a study was made of the dia-magnetic susceptibilities of nitric acid solutions at different concentrations. It was found that the susceptibility-concentration curve departed appreciably from a linear relation and that deviations occurred at concentrations corresponding to some known hydrates. The present communication deals with the investigation of the dia-magnetic susceptibilities of sodium and potassium nitrate solutions. The choice of the salts was dictated by two considerations. In the first instance, these salts have not been thoroughly investigated for their magnetic susceptibilities in solutions. Secondly, as we had already studied the susceptibility of nitric acid, the investigation of other nitrates was expected to yield some information with regard to the influence of kation on the susceptibility of the  $\text{NO}_3^-$  ion.

## E X P E R I M E N T A L

The experimental arrangement was essentially the same as that used in our work on nitric acid. Two narrow glass tubes of equal and uniform bore, each

connected by a glass tubing to a wider tube so as to form a sort of U-tube, were placed vertically and side by side between the parallel pole-pieces of an electromagnet. One of the U-tubes contained the standard liquid, benzene, selected for its non-sticking property and the other, the solution, whose susceptibility was to be determined. The value for benzene was found to be  $-0.704 \times 10^{-6}$  in comparison with that of water ( $-7.10 \times 10^{-6}$ ). The displacement of the liquid levels in the tubes was recorded photographically by throwing an oblique beam of light from a powerful incandescent lamp placed in front of the U-tubes. When the tubes are illuminated horizontally, full images of the tubes with their contents, are obtainable on the camera screen; but when the light source is gradually displaced below the horizontal line, a position is ultimately reached when everything, except the two menisci, disappear completely from the field of view.

This arrangement is of great advantage inasmuch as it enables one to obtain simultaneous and almost instantaneous records of changes in the levels of the two liquids and thus to avoid all possible errors due to irreproducibility of the magnetic field and different heating effects, which are difficult to avoid where only one liquid is under observation at a time.

The tubes were thoroughly cleaned before each experiment, the solutions showing no sign of sticking. In the course of experiments, readings were also taken with the same liquid in both the tubes and corrections applied for the very slight differences in the displacement of liquids in the two tubes.

The electromagnet used was a large-size Pyc's Electromagnet, capable of giving a field of about 25,000 gauss with a current of 10 amps. at 110 volts. The magnet was excited for a few seconds only for each exposure. The salts were Kahlbaum's pure reagents, purified by further re-crystallisation and carefully dried. They were found free from para-magnetic impurities.

#### R E S U L T S

The relative displacements of the menisci of the two liquids, as recorded on the photographic plate, were measured with the help of the Hilger Micrometer. In doing this, care was taken to focus the cross-wires at the centres of the menisci in each case. The ratio of the displacements gave the ratios of the susceptibilities after a correction had been applied for the para-magnetic effect of the air-vapour mixture above the liquid column. The results are given in the tables below. The susceptibility value given for each concentration is the average of results obtained from three different records.

TABLE I

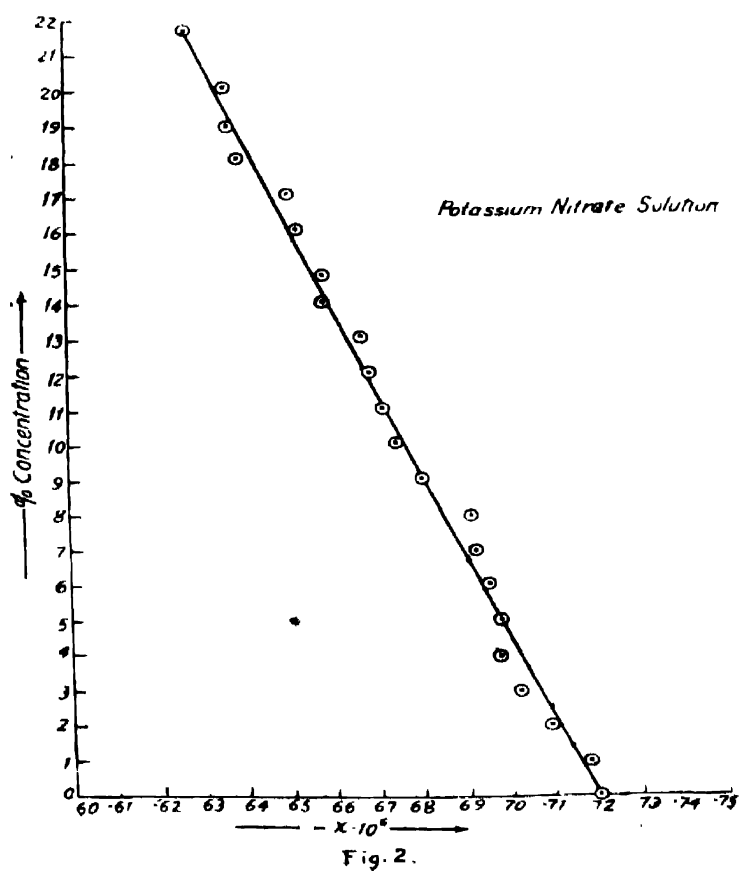
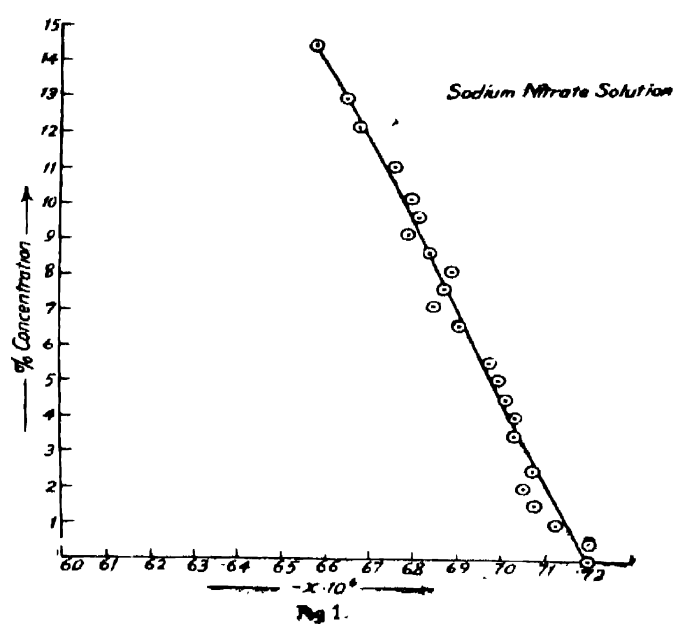
*Magnetic Susceptibilities of Sodium Nitrate Solutions*

Gm. NaNO <sub>3</sub> in 100 gms. of solution	$-\chi \times 10^6$	Gm. NaNO <sub>3</sub> in 100 gms. of solution	$-\chi \times 10^6$
14.78	0.653	5.40	0.692
12.75	0.660	5.0	0.698
11.99	0.664	4.5	0.700
10.9	0.671	4.0	0.702
10.0	0.675	3.5	0.702
9.5	0.677	3.0	0.706
9.0	0.675	2.0	0.705
8.5	0.680	1.5	0.707
8.0	0.685	1.0	0.712
7.5	0.681	0.50	0.720
7.0	0.682	0.0	0.720
6.5	0.688		

TABLE II

*Magnetic Susceptibilities of Potassium Nitrate Solutions*

Gm. KNO <sub>3</sub> in 100 gms. of solution	$-\chi \times 10$	Gm. KNO <sub>3</sub> in 100 gms. of solution	$-\chi \times 10$
21.6	0.625	10.0	0.674
20.0	0.634	9.0	0.680
18.9	0.635	8.0	0.691
18.0	0.637	7.0	0.692
17.1	0.649	6.0	0.695
16.0	0.651	5.0	0.698
14.82	0.657	4.0	0.697
14.0	0.657	3.0	0.702
13.0	0.666	2.0	0.709
12.0	0.668	1.0	0.718
11.0	0.671	0.0	0.720



CONCLUSIONS

The changes of susceptibility with concentration in the case of both the solutions can be represented graphically by a straight line (Figs. 1 and 2), the maximum deviation from linearity being not more than 1% in each case. The equations for the two graphs are as follows :—

$$\text{For sodium nitrate solution} \quad Z = 0.72 + 0.0041 \times C,$$

$$,, \text{ potassium nitrate solution} \quad Z = 0.72 + 0.0041 \times C,$$

where  $Z$  and  $C$  represent the susceptibility and concentration, respectively. From these equations, the gram-susceptibilities of sodium and potassium nitrate come out to be  $-0.28 \times 10^{-6}$  and  $-0.31 \times 10^{-6}$  respectively. These values, multiplied by the molecular weights of the salts, yield the following values for the gram-molecular susceptibilities of the two salts in the dissolved state :

$$\text{Sodium nitrate} \quad -23.86 \times 10^{-6}$$

$$\text{Potassium nitrate} \quad -31.62 \times 10^{-6}$$

Brindley and Hoare<sup>2</sup> have recently determined, with a great deal of precision, the gram-molecular susceptibilities of alkyl halides in the solid state, which are fairly additive. The ionic susceptibilities derived from this set of values show a fairly good agreement with the values, calculated theoretically by Angus for the free ions, except in the case of  $\text{Na}^+$ , for which the experimental value is  $-6.1 \times 10^{-6}$ , whereas the theoretical value is  $-3.7 \times 10^{-6}$ . The experimental value for  $\text{K}^+$  ( $-14.6 \times 10^{-6}$ ) is greater than the theoretical value ( $-13.1 \times 10^{-6}$ ). Taking these theoretical values as approximately true for  $\text{Na}^+$  and  $\text{K}^+$  in solution, the values for the gram-ionic susceptibility of  $\text{NO}_3^-$  calculated from the gram-molecular susceptibilities of the two salts are shown in the following table. The value for the susceptibility of  $\text{NO}_3^-$  arrived at from our previous measurements with  $\text{HNO}_3$  and the theoretical values are also given.

Gram-ionic susceptibility of  $\text{NO}_3^-$  ( $-\chi \times 10^6$ )

Experimental value			Theoretical value	
From measurement with $\text{HNO}_3$ in solution	From measurements with $\text{NaNO}_3$ in solution.	From measurements with $\text{KNO}_3$ in solution.	Angus <sup>3</sup>	Pauling <sup>4</sup>
20.8	20.1	18.5	34	38

It appears that the value for  $\text{NO}_3^-$  is different in the three combinations, being least in the case of the potassium salt. But in view of the fact that there is no general agreement between the values for the ionic susceptibilities of sodium and potassium arrived at by different workers and the theoretical values calculated by different methods, no definite conclusion can be drawn from the above results with regard to the influence of the positive ion. It is, however, clear that the experimental values are, on the whole, less than the theoretical value for  $\text{NO}_3^-$ , which is an indication of ionic deformation.

## R E F E R E N C E S

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